Unit B Conclusion

Throughout Unit B you witnessed the significant role motion plays in your life. The fact that you need to move from one place to another automatically means that you interact on a daily basis with a variety of transportation technologies. Acceleration lanes on highways, crumple zones in automobiles, and the latest innovations in air-bag technology are all designed using science concepts you studied in this unit. In each case, the goal is to help you reach your destination safely.

A key theme in this unit has been the idea that science and technology are influenced and supported by society. Legislation related to the mandatory use of seat belts in cars and the mandatory use of helmets while riding motorcycles speaks to the strong connections among science, technology, and society (STS). As you study the other units in this course and as you continue your studies beyond high school, you will notice that these STS connections have a profound influence on almost every aspect of your life.

Career Profile

Mechanical Engineer

Brendan Montour always knew he would do something technical in life, because his fascination with mechanical devices began when he was very young. "It started with bicycles and snowmobiles; then I moved on to motorcycles and cars." He learned to fix things by taking them apart and putting them back together.

The skills he developed helped to get him summer jobs. At 18, he was an instrument technician for the concrete work in the building of Kahnawake's sports complex. The following year, he did land surveying for pipe installation. These jobs led him to study engineering at Concordia and, eventually, to his current job as the Director for Public Works in Kahnawake.

Brendan graduated from Concordia in 1997. "I like to be challenged," he says, "and with the workload in university, there were plenty of challenges." Two of the hardest were "being able to get all the work done on time and lack of sleep." He got through it by adopting the philosophy that it was better to hand in a good paper on time than a perfect one a week late. This lesson has led him to encourage students to strive for perfection but to balance it with flexibility so they can deal with the bumps on the road.

As the Director of Public Works, Brendan is responsible for eight departments—three of which are connected to transportation: the Roads Department, Highway Maintenance, and School Bus Transportation. As such, he has to ensure that all local roads and transportation systems are safe and maintained, which takes "a lot of planning and reviewing of maintenance practices."

The main tasks of the Roads Department are the snow removal in the winter and grass cutting along roads in the summer. Kahnawake recently took over the maintenance on the highways that run through the community from the Quebec Ministry of Transport, which meant hiring more people and purchasing more equipment.

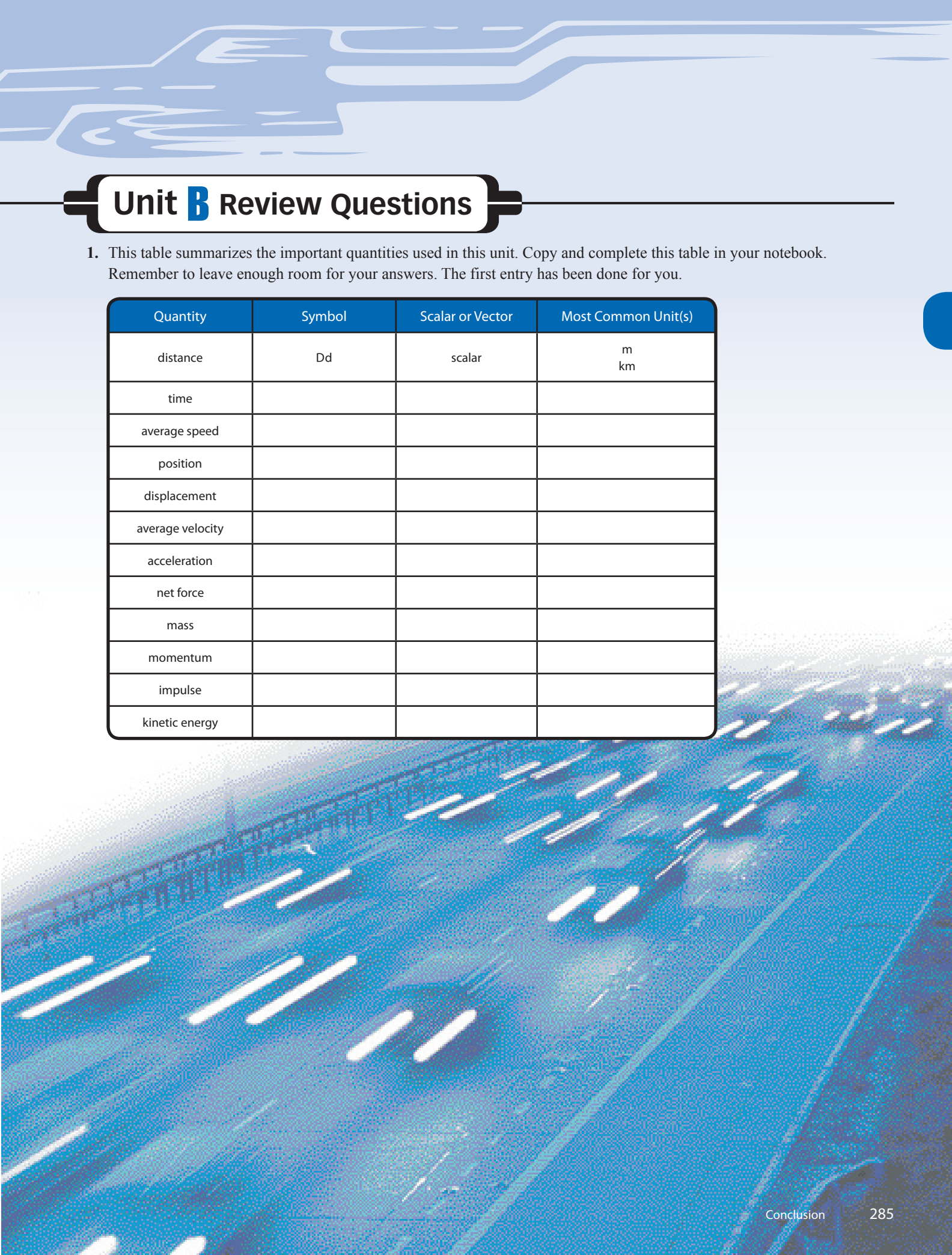
Brendan is glad he went into the sciences because he says, "Science gives you a greater understanding of the natural world." But he knows science may not be for everyone, so he tells students to "decide what is best for you." Still, he believes that a post-secondary education "opens the way to meaningful employment" through which you can "help your community by adding to the local pool of expertise."

In his own time, Brendan really enjoys spending time with his family and being outdoors. He also races his dirt bike with his brothers in competitions and likes to hunt and fish.

Unit B Review Questions

1. This table summarizes the important quantities used in this unit. Copy and complete this table in your notebook. Remember to leave enough room for your answers. The first entry has been done for you.

Quantity	Symbol	Scalar or Vector	Most Common Unit(s)
distance	Dd	scalar	m km
time			
average speed			
position			
displacement			
average velocity			
acceleration			
net force			
mass			
momentum			
impulse			
kinetic energy			



2. In this unit you were introduced to a number of equations involving the variables listed in question 1. Copy the following table into your notebook. Complete this table by matching at least one application to each of the key equations from this unit. The first equation from this unit has been completed as an example.

Equation	Application "This equation can be used to determine the . . ."
$\bar{v} = \frac{\Delta \bar{d}}{\Delta t}$	• average velocity of a glacier's retreat • displacement of a vehicle on a highway during a driver's reaction time • time a vehicle takes to reach an object illuminated at the end of the headlights' beam
$\bar{a} = \frac{(\bar{v}_f - \bar{v}_i)}{\Delta t}$	
$\Delta \bar{d} = \frac{1}{2}(\bar{v}_f + \bar{v}_i)\Delta t$	
$\Delta \bar{d} = \bar{v}_i \Delta t + \frac{1}{2}\bar{a}(\Delta t)^2$	
$\bar{F}_{net} = m\bar{a}$	
$\bar{p} = m\bar{v}$	
$\bar{F} = \frac{\Delta \bar{p}}{\Delta t}$	
$\bar{F}_{1 \text{ on } 2} = -\bar{F}_{2 \text{ on } 1}$	
$\sum \bar{p}_{\text{before}} = \sum \bar{p}_{\text{after}}$	
$E_k = \frac{1}{2}mv^2$	
$W = Fd$	

Applying Concepts

Use the following information to answer questions 3 and 4.

Young children are protected while travelling in vehicles with specially designed car seats and booster seats. When pregnant women are in the last stages of pregnancy, their unborn children are much harder to protect during a motor vehicle collision.

Figure B.1: In a collision, it is difficult to protect unborn children of pregnant women in their last stage of pregnancy.

It is estimated that each year there are three times as many fetuses in the second and third trimesters killed in motor vehicle collisions than there are children under 4 years of age killed in motor vehicle collisions. Researchers are investigating solutions to this problem by developing computer models geared to improve the designs of seat belts, air bags, and steering wheels for pregnant women.

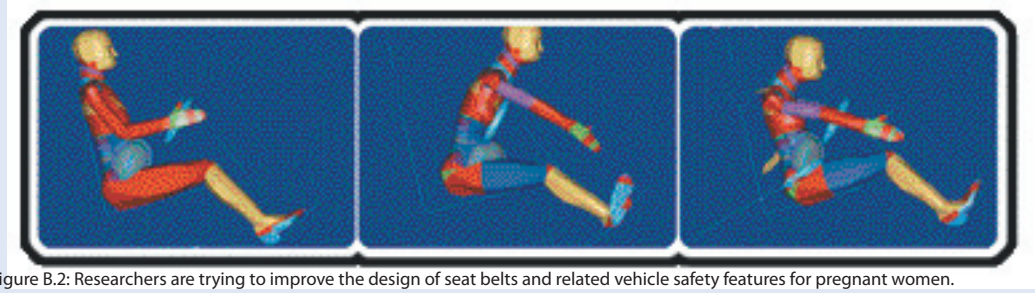


Figure B.2: Researchers are trying to improve the design of seat belts and related vehicle safety features for pregnant women.

3. Consider the photo of the pregnant woman driving the car. Suppose this car was moving and was then involved in a collision and suddenly came to a stop.

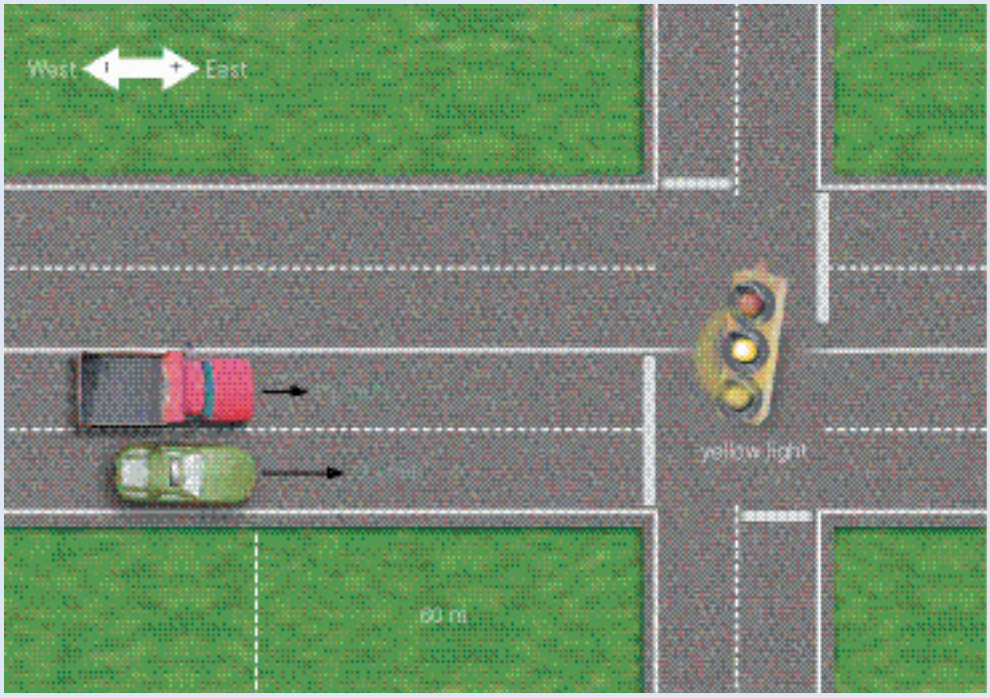
- **a.** Use Newton's laws of motion to explain the motion of the driver in the fraction of a second immediately after impact.
- **b.** List at least three technologies that would act to help reduce her injuries.
- **c.** Use the idea of impulse to explain how a seat belt would reduce the severity of the injuries to the driver.
- **d.** Explain why the design of the seat belt and the position of the steering wheel is particularly important if the driver is a pregnant woman.

4. Suppose the driver has a mass of 58.5 kg and is travelling 65.5 km/h, east.

- **a.** Calculate the momentum of the driver in kg□m/s.
- **b.** Determine the driver's momentum after the collision.
- **c.** Determine the impulse required to decelerate the driver from an initial velocity of 65.5 km/h, east, to rest.
- **d.** Calculate the force required to stop the driver's forward motion if she comes to a stop in 0.900 s.
- **e.** Calculate the force required to stop the driver's forward motion if she comes to a stop in only 0.090 s.
- **f.** Refer to your answers to 4.d. and 4.e. to the images from the computer model in Figure B.2. Which image from this model best matches the calculation in question 4.d.? Which image best matches the calculation in question 4.e.? Explain the significance of your answer to occupants of vehicles during car crashes.

Use the following information to answer questions 5 to 8.

The following diagram shows two vehicles approaching an intersection. At the instant shown, the truck is travelling 60.0 km/h, east, and the car is travelling 72.0 km/h, east. At this moment, both vehicles are 60.0 m from the intersection when the traffic light turns yellow.



5. Suppose the driver of each vehicle has a reaction time of 1.50 s.

a. Determine the displacement of each vehicle while the driver is reacting to the yellow light.

b. State the proper name for the magnitude of each value you calculated in question 5.a.

6. At the end of the 1.50-s time interval, each driver begins to brake.

a. Use the standard deceleration value of 5.85 m/s^2 to determine the additional time required for each vehicle to stop. Use the time values to determine the distance travelled by each vehicle while braking.

b. State the proper name for the values that you calculated in question 6.a.

7. The total distance travelled by each vehicle can be found by adding the distance travelled by the vehicle while the driver was reacting to the distance travelled by the vehicle while the driver was braking.

a. Determine the stopping distance for each vehicle.

b. Each vehicle began the process of coming to a stop at a displacement of 60.0 m, west of the intersection. Use a scale diagram to determine the final position of each vehicle relative to the intersection. On your scale diagram, let the start of the intersection be considered the reference position (zero point) and let the initial position of the vehicles have a value of -60.0 m.

8. For this intersection, the light remained yellow for 2.8 s. Suppose the driver of the car decided not to stop for the yellow light, but instead decided to continue through the intersection while the light was yellow.

a. Determine the displacement of the car during the 2.8-s time interval of the yellow light if the driver maintained the velocity of 72 km/h.

b. Use a scale diagram to determine the final position of the car relative to the intersection. On your diagram, let the start of the intersection be considered the reference position (zero point) and let the initial position of the car to be -60.0 m.

c. Should the driver of the car maintain the car's velocity, or should the driver brake? Evalulate the options for dealing with the yellow light for the driver of the car. If neither option is satisfactory, identify the possible causes of this driver's dilemma.

Use the following information to answer questions 9 to 16.

A student collected the following data from a skateboard moving on two different ramps: Ramp A and Ramp B.

RAMP A

Time (s)	Position (cm)	Average Velocity (cm/s)	Midpoint Time (s)
0	0.0		
0.50	7.6		
1.00	19.4		
1.50	35.2		
2.00	54.2		
2.50	76.6		
3.00	102.4		

RAMP B

Time (s)	Position (cm)	Average Velocity (cm/s)	Midpoint Time (s)
0	0.0		
0.50	39.2		
1.00	73.6		
1.50	104.0		
2.00	129.8		
2.50	151.0		
3.00	168.4		

9. Copy these tables into your notebook or into a spreadsheet. If using a spreadsheet, insert an extra line for the interval values. Complete the tables by calculating the average velocity and average time values for each of the half-second time intervals.

10. Create a position–time graph for Ramps A and B.

11. Describe the motion of the skateboard on Ramp A.

12. Describe the motion of the skateboard during Ramp B. Refer to the graphs to support your answer.

13. Create a velocity–time graph for Ramp A.

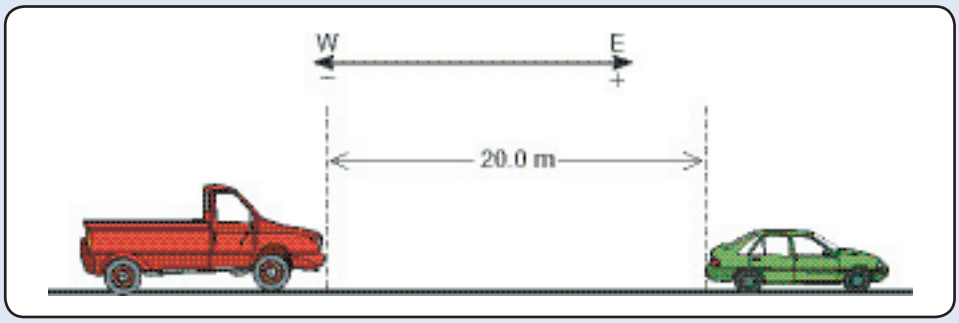
14. Create a velocity–time graph for Ramp B.

15. Use the velocity–time graphs to determine the acceleration of the skateboard for both Ramp A and Ramp B.

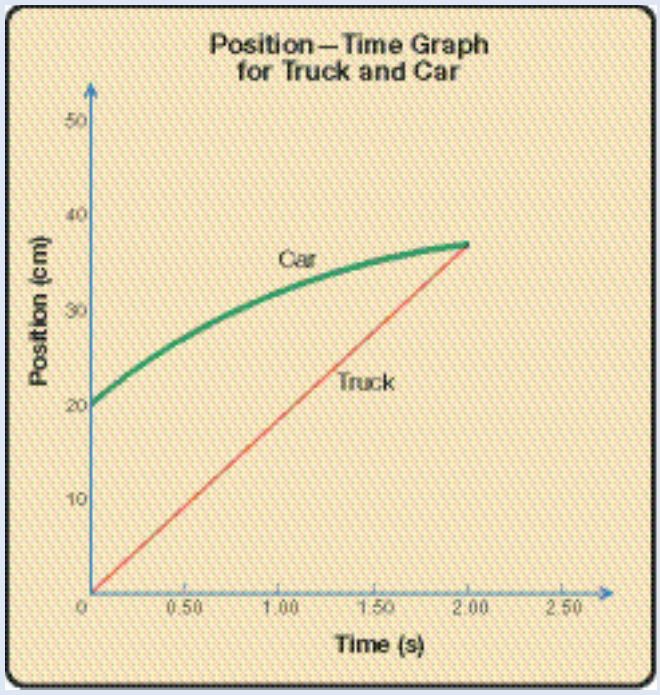
16. Sketch a diagram of the apparatus to show how you think the data was collected from the two ramps in this experiment. Be sure to include an indication of which ramp was steeper.

17. Use the following information to answer questions 17.a. to 17.c.

A 1200-kg truck is travelling 70.0 km/h[E]. The truck is 20.0 m behind a 900-kg car travelling at the same velocity in the same direction. The driver of the car spots an obstacle on the road and immediately applies the brakes to slow down. The driver of the truck sees the brake lights of the car and slams on the brakes. However, the reaction time of the driver in the pickup truck is 2.00 s.



A graph displaying the position of each vehicle as a function of time is shown.



a. Identify the type of motion depicted by the graph for the truck.
b. Identify the type of motion depicted by the graph for the car.
c. Describe the event that occurs at 2.00 s.

18. Collisions are often the consequence of one vehicle following another vehicle too closely. This is commonly referred to as "tail gating." A truck, with a mass of 1200 kg and a velocity of 19.4 m/s[E], rear-ends a 900-kg car travelling 7.20 m/s[E]. After the impact, the two vehicles stick together.

a. Use the law of conservation of momentum to determine the velocity of the two vehicles after the collision.
b. Calculate the change in momentum of the truck.
c. Determine the impulse on the truck.
d. If the time of impact was 1.30 s, calculate the force on the truck.

19. Suppose the truck, with a mass of 1200-kg and velocity of 19.4 m/s[E], rear-ends the 900-kg car. At the moment of impact, the car had decelerated to a velocity of 7.20 m/s[E]. After an impact time of 1.30 s, the truck slows to 12.0 m/s[E] while the car is propelled forward by the collision.

a. Using the law of conservation of momentum, calculate the final velocity of the car.
b. Determine the change in momentum of the truck.
c. Determine the change in momentum of the car.
d. Are the magnitudes of the change in momentums the same for both vehicles? State the law that justifies your answer.
e. Calculate the impulse of the truck on the car.
f. Calculate the impulse of the car on the truck.
g. Are the impulses on both vehicles the same?
h. Determine the force of the truck on the car.
i. Determine the force of the car on the truck.
j. Are the forces on each vehicle the same? State the law that justifies your answer.
k. If the force compresses the rear of the car by 0.300 m, how much work was done?
l. How much energy is required to do this work?

From the Science 20 Textbook CD, view the video "Career Profile: Accident Reconstruction." Use the information provided to answer questions 20 and 21.

20. Do forensic engineers determine who was at fault in a collision?

21. Complete the following chart.

COLLISION RECONSTRUCTION

Data Collected by Forensic Engineer at Scene of Collision	Science Terms and Concepts Used in Analyzing Data	Information About Collision Derived from Data
length of skid marks left on roadway		
amount of crumpling or deformation of metal parts		
rest positions of the vehicles at the scene of a collision		